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Vol. 46 No. 8

BULLETIN

OF THE

TORREY BOTANICAL CLUB

AUGUST, 1919

A new Matonidium from Colorado, with remarks on the distribution of the Matoniaceae

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(WITH PLATES 12 AND 13 AND TWO TEXT FIGURES)

In 1916 Professor Cockerell, of the University of Colorado, published a brief note* based upon plant material collected from the supposed McElmo formation of southwestern Colorado. The subsequent discovery that this supposed Lower Cretaceous flora was stratigraphically above a black shale horizon carrying a considerable dicotyledonous flora led to the sending of all of the material to the present writer for a more critical study than Professor Cockerell was able to devote to it.

The discussion of the question of the stratigraphic relations and age of these two floras is reserved for a subsequent communication, the present paper being devoted to the interesting questions of habit and distribution derived from a study of the abundant relics of *Matonidium* preserved in the later of the two floras above mentioned.

The Colorado remains, which Professor Cockerell identified as *Matonidium Althausii*, or *Matonidium Goepperti* as some paleobotanists prefer to call the species on the ground that the older and correct name is less familiar, are superficially very much like that well-known and rather variable species. Botanists who

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* A Lower Cretaceous flora in Colorado. Jour. Wash. Acad. Sci. **6**: 109–112. *pl. 1, 2.* 1916.

[The BULLETIN for July (**46**: 235–284) was issued July 31, 1919.]

depreciate specific differentiation and who, like Professor Seward, are more interested in the former distribution of generic types, would not hesitate to refer the Colorado form to *Matonidium Althausii.* Such questions are always difficult, and tastes and temperaments differ with individual workers. One point of view may serve one purpose and the other another. All that need be insisted upon in the present connection is that the framing of loosely defined specific limits as opposed to finely discriminated ones effectually obscures whatever value the fossils may have for the elucidation of geologic chronology or problems of the former time and avenues of migration, and is a method that has gradually become almost obsolete in the allied field of paleozoölogy.

It would seem *a priori* incredible that a single botanical species should range through the Jurassic and Lower Cretaceous and extend over at least two continents in opposite hemispheres; nevertheless it is impossible to differentiate the British Jurassic from the Wealden forms or these from the still younger Russian occurrences, and the specimens referred by Ward to *Matonidium Althausii* from the Albian Fuson formation of the Black Hills* in this country cannot be distinguished from the earlier European occurrences of that species.

Recognizing fully the individual variability in *Matonidium Althausii* and the variation in the form and size of the pinnules from different parts of a single frond, the Colorado *Matonidium* nevertheless presents a number of apparently constant peculiarities that serve to mark it as a slightly but consistently different type. Among these distinctive features might be mentioned the stouter stipe and rachises, the more numerous pinnae, which appear to have been at least twice as numerous as in *Matonidium Althausii*, judging from the frond bases of the latter as figured by Ettingshausen, Schenk and Seward. The pinnae are more slender in the Colorado form and the pinnules are shorter and wider with fewer and more nearly circular or isodiametric sori. For example, in the form of *Matinidium Althausii* described from the Black Hills the falcate slender pinnules are twice as long as in the Colorado material, and each bears about twelve pairs of sori. The Portuguese specimens as figured by Heer† show eighteen pairs of sori to each pinnule, Schenk's admirable figures* show eight or nine pairs, and they are very numerous in Trautschold's figures of the Russian material.† The most elongate and largest pinnules of the Colorado species bear but five or six sori on the distal half of the lamina and but six or seven on the proximal half, while the most abundant remains are those with short and broad pinnules bearing three sori on their distal halves and four sori on their proximal halves.

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* Ann. Rep. U. S. Geol. Surv. 19^2: 653. *pl. 160, f. 5–8.* 1899.

† Secc. Trab. Geol. Port. 16. *pl. 15, f. 1–6.* 1881.

I regard these features and others to be mentioned as of specific value and propose that the Colorado specimens be discriminated as

Matonidium americanum sp. nov.

Matonidium Althausii Cockerell, Jour. Wash. Acad. Sci. **6**: 111. *f. 2.* 1916. [Not (Dunker) Ward.]

Cycadospadix? sp. Cockerell, *Idem.* 110. *f. 1.*

This species also includes forms which Cockerell suggested might represent *Todites*, and *Weichselia* or *Cladophlebis*. The equisetaceous stems mentioned as probably representing *Equisetum Burchardti* (Dunker) Brongniart are probably fragments of the large stipes of *Matonidium*. The striations are somewhat irregular and do not alternate at the nodes, there are no traces of nodal sheaths and the apparent jointing appears to be due to shrinkage cracks of a collapsed and consequently furrowed stipe, since a similar state of preservation is seen in the objects that were referred to *Cycadospadix*, which latter are clearly the apical portions of *Matonidium* stipes and only most superficially suggestive of *Cycadospadix*, and strictly comparable with similar remains of *Matonidium Althausii* as figured by Schenk,‡ Ettingshausen§ and Seward.||

Matonidium americanum may be characterized as follows: Digitate fronds with the same habit as *Matonidium Althausii* or the existing *Matonia pectinata*, with long stout stipes about 1 cm. in diameter as preserved in a partially flattened condition. Stipe surface somewhat regularly furrowed, but whether this was

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* Palaeont. **19**: 220. *pl. 27, f. 5; pl. 28, f. 1, 2; pl. 30, f. 3; pl. 42, f. 1.* 1871.

† Nouv. Mém. Sci. Nat. Moscou **13**: 28. *pl. 19, f. 3.* 1870.

‡ Palaeont. **19**: *pl. 42 f. 1.* 1871.

§ Abh. k. k. Geol. Reichs. **13**: *pl. 5. f. 4, 6.* 1854.

|| Jurassic Fl. **1**: *pl. 11, f. 1.* 1900.

an original feature or is due to collapse during fossilization is undeterminable. Distad the stipe expands into a flabellate recurved or reflexed "collar" which shortly divides to form the axes of the pinnae, whose attitude in life was transverse or reflexed with respect to that of the vertical stipe. These reflexed "collars" are especially common in the rocks and are the objects which Cockerell referred to *Cycadospadix*. They are well shown in PLATE 12, FIGS. 9–12.

The width of the "collar" before it split up into pinnae varies from specimen to specimen and is not always clear, although it is narrowest medianly. No traces of pinnules have been found in actual connection with these stipes although they are in close association. The divisions of the "collars," however, do not terminate as they would if the fossils were of the nature of *Cycadospadix*, and the breaks at the ends are obviously mechanical and not natural. The evidence of their reflexed form is also clear, and the size of the segments, their condition of preservation and furrowing are in exact agreement with the specimens of proximal pinnae axes. The number of pinnae was large but somewhat variable. The "collar" shown in FIG. 9. indicates four lateral pinnae at each end of the collar and thirty-one additional intercalated pinnae, making thirty-nine in all. FIG. 10 shows clear traces of at least twenty-five pinnae, and FIG. 12, which is the counterpart of the apex of the specimen shown in FIG. 11, shows the bases of thirty-six pinnae. The pinnae were therefore much more numerous than the published figures indicate for *Matonidium Althausii* and also somewhat more numerous than the normal number in the modern *Matonia pectinata*. The exact length of the pinnae is unknown since all are preserved in a fragmentary condition, but judging by the fragments of proximal, medial and distal parts preserved, and the size and degree of tapering of the rachises, they could not well have been shorter than 20–25 cm., or about the same length as in the admirable specimen of *Matonidium Althausii* figured by Schenk* from the German Wealden. Their width, however, was much less than in that species, the largest certainly identified (PLATE 12, FIG. 8) being but 11 mm. across, while the more abundant remains (PLATE 12, FIG. 2) are about 8 mm. in width. Several sterile fragments which I have referred to this species on the basis of general form and association are somewhat larger (PLATE 12, FIG. 7) being 15 mm. wide. These show a narrower rachis with slightly less obtuse pinnules which are greatly crowded, and may represent fragments of a contemporaneous species of *Cladophlebis*. Fertile fragments of pinnae present a very different appearance when the opposite faces are viewed. From below the rachis appears very stout and the laminae of the pinnules is entirely hidden by the large sori except for a broad band in the position of the midvein. Viewed from above the rachis is much narrower, the pinnules evidently having been inserted near the upper margin of the rachis as shown in the section (PLATE 13, FIG. 4).

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* Palaeont. 19: *pl. 28, f. 1.* 1871.

The pinnules are short and broad, more or less falcate, obtusely rounded at their tips. All have revolute margins and they are opposite or sub-opposite in position. Their substance is thick and the venation cannot be made out in any of the preserved material. Distad along the rachis the pinnules gradually become shorter and somewhat broader relatively (PLATE 12, FIG. 6), eventually becoming very small and coalescent basally (PLATE 12, FIG. 3, 4), their revolute margins giving them a pointed appearance. Proximad along the rachis the pinnules gradate through short and broad forms to short wide scallops as shown in PLATE 12, FIG. 5.

The sori are in two rows separated by a broad space in the region of the midrib. They diminish in size toward the pinnule tips and are prevailingly circular except where mutual crowding causes the lateral margins to be somewhat flattened. They stand out from the surface of the pinnules as prominent umbos and a pronounced umbilicus on the indusium marks the position of the central soral axis. The indusia are peltate and are intact in all of the Colorado material so that the number of sporangia can not be made out. In *Matonidium Althausii* the sori are said to have been more numerous than in the modern *Matonia pectinata*, sections of a sorus of the latter species being introduced for comparison on PLATE 13, FIGS. 1, 2. In the bulk of the material each pinnule shows three or four upper and four or five lower sori (PLATE 13, FIG. 3). These were the only forms in the collection which Professor Cockerell had labelled *Matonidium Althausii*. In the largest fruiting material there are six or seven sori on the distal halves of the pinnules and seven or eight on their proximal halves, (PLATE 13, FIG. 6), a less number than in *Matonidium Althausii*, as already remarked. The sori also differ from those of the latter in being isodiametric instead of transversely elongate and more or less rectangular.

The material, which was collected by J. T. Duce, comes from the divide between Cutthroat Gulch and Hovenweep Canyon west of Dolores and is contained in a light somewhat ferruginous sandstone containing little quartz and a great deal of feldspar, and apparently corresponds to what Cross correlated with the Dakota sandstone in the San Juan region of Colorado.

The family Matoniaceae is one of exceptional botanical interest. Its sole existing genus, *Matonia* R. Brown (1830), contains but two known species which differ remarkably in vegetative habit and are both confined to the uplands of the Malay Peninsula and the island of Borneo. The older and only species known up to 1888 was commonly associated with the family Cyatheaceae, although its intermediate character had usually resulted in its being set apart as a special tribe. It has also been associated with the Gleicheniaceae and the Polypodiaceae. Christ (1897) and most subsequent workers have regarded *Matonia* as the sole existing type of a distinct family, and an admirable account of the genus and of some of its fossil relatives was given by Seward in 1899.*

The extinct genus *Matonidium*, to which the Colorado plant is referred, was a characteristic type of the Jurassic and especially of the Lower Cretaceous. Although known as early as 1843 its botanical affinity was first recognized by Schenk in 1871 and it has subsequently been found to have been widespread in the European region and more sparingly represented in the western United States. Most of the occurrences have been referred to the single species *Matonidium Althausii*, although Krasser† has described a well characterized species from the Upper Cretaceous (Cenomanian) rocks of Moravia, which appears to have also been present in rocks of the same age in Bohemia.

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* Phil. Trans. Roy. Soc. Lond. **191B**: 171–209. *pl. 17–20.* 1899.

† Beitr. Paläon. Oesterreich-Ungarns **10**: 119. *pl. 11, f. 1; pl. 12, f. 1, 2; pl. 17, f. 10.* 1896.

These occurrences are assembled upon the accompanying sketch map (TEXT FIG. 1) and are shown within the enclosed areas in Europe and North America. The area of distribution of the two existing species of *Matonia* is shown on the map in solid black. A second rather well-known extinct genus belonging to this family is the genus *Laccopteris*, which was founded by Presl in 1838. *Laccopteris* was especially characteristic of the late Triassic and hence was considerably older in its inception than *Matonidium*. Its relationship with *Matonia* was first clearly defined by Zeiller* in 1885. Reference to the accompanying map (TEXT FIG. 1), where the occurrences of *Laccopteris* are indicated by L, shows that it greatly extends the Mesozoic range of the family and gives the Matoniaceae representation in the far north (Greenland and Spitzbergen), in the Asiatic region and in Australia. Other and less well known fossil genera which have been referred to the Matoniaceae include *Phlebopteris* Brongniart, *Microdictyon* Saporta and *Knowltonella* Berry.

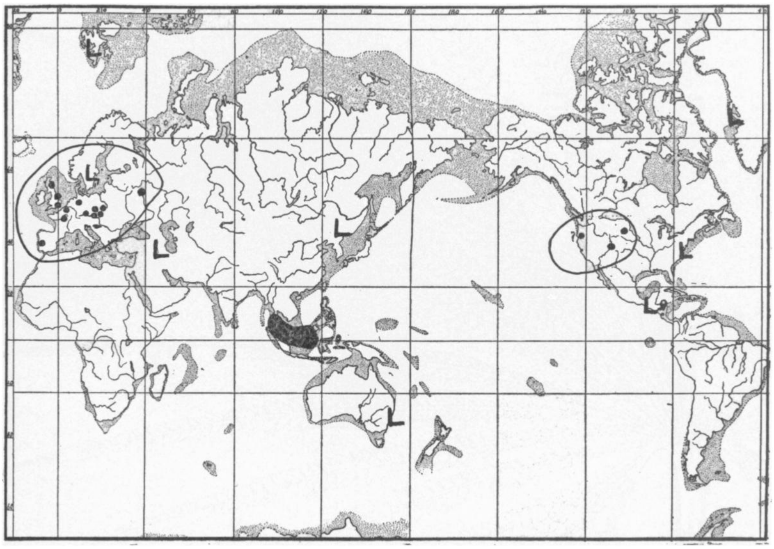

FIG. 1. Sketch map showing the area of distribution of the two existing species of *Matonia* (solid black), the fossil occurrences of *Matonidium* (black disks within the enclosed areas), and the fossil occurrences of *Laccopteris* where they do not coincide with occurrences of *Matonidium* (L).

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* Bull. Soc. Bot. France 32: 22. 1885.

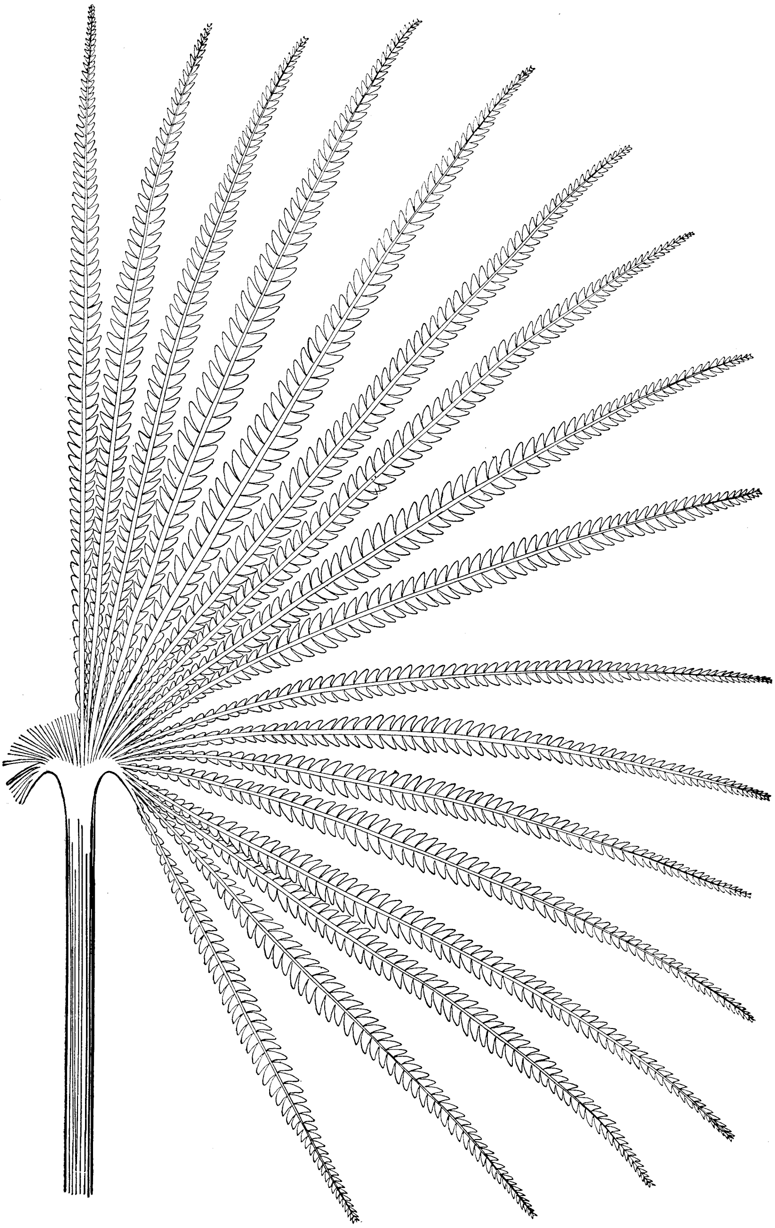


FIG. 2. Restoration of *Matonidium americanum* Berry, two fifths natural size.

The accompanying restoration of *Matonidium americanum*, shown in TEXT FIG. 2, is based upon a considerable amount of material which, although fragmentary, supplies data for all parts of the frond. Its abundance in the small collection from this one locality would seem to indicate that the species was gregarious, sending up its stout stipes from a creeping rhizome as does the modern *Matonia pectinata*. The reduced figure was made from a life size drawing made by plotting the various fragments of the different parts to scale, and the arrangement of the pinnae is based upon their disposition in *Matonia pectinata* and the evidence derived from the numerous fossil frond bases ("collars") preserved. Whether the stipe in the fossil species was as elongated as in the modern *Matonia pectinata* is not known. At the apex the stipe of *Matonidium americanum* was less distinctly dichotomous with less scirpoid branches than in *Matonia pectinata*, one side of the stipe becoming concave and the whole forming a reflexed fan-like base from which the rachises of the numerous pinnae proceded. In life these were not upright as in the restoration but were turned back ninety degrees or more giving the fronds an almost peltate appearance.

Explanation of plates 12 and 13

PLATE 12

MATONIDIUM AMERICANUM Berry

FIG. 1. Under side of fertile pinna showing stout furrowed rachis.
FIG. 2. Under side of fertile pinna showing normal size and form.
FIG. 3. Upper side of apical portion of pinna.
FIG. 4. Portion of same, × 10.
FIG. 5. Basal part of pinna from below.
FIG. 6. Upper part of pinna from above.
FIG. 7. Maximum size of rare occurrence, from above.
FIG. 8. Fragment from below showing maximum development of sori.
FIG. 9. Apex of stipe showing indications of 39 pinnae.
FIG. 10. Apex of stipe with 25 pinnae.
FIG. 11. Apex of stipe of another specimen.
FIG. 12. Counterpart of apex of specimen shown in 11 with indications of 36 pinnae.

PLATE 13

FIGS. 1, 2. MATONIA PECTINATA R. Br.

FIG. 1. Lamina and sorus in vertical section showing indusium (black) and sporangia.

FIG. 2. Sorus in transverse section showing central pillar and sporangia with annuli.

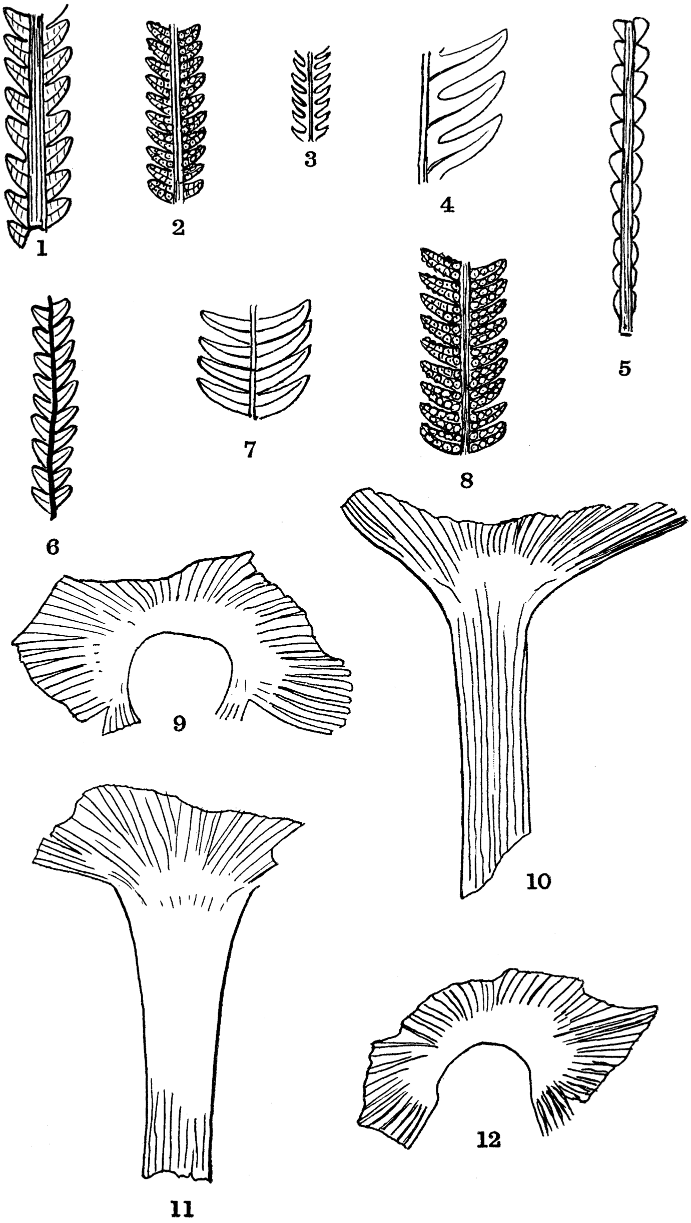
FIGS. 3–6. MATONIDIUM AMERICANUM Berry

FIG. 3. Two pinnules of normal form from below to show form and position of sori, × 10.

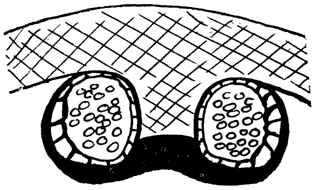
FIG. 4. Same in longitudinal vertical section, × 10.

FIG. 5. A single pinnule in transverse section showing sori and revolute margins, × 10.

FIG. 6. Two pinnules of the large form with maximum number of sori, from below, × 10.



MATONIDIUM AMERICANUM BERRY



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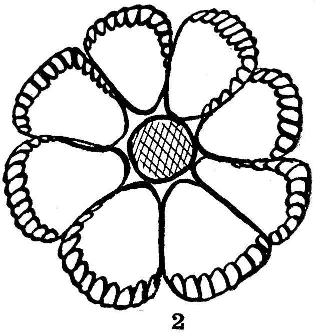

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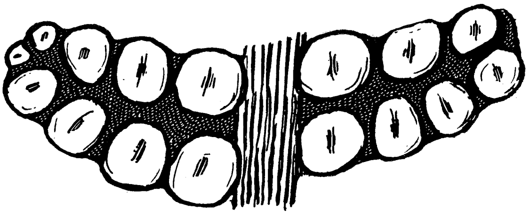

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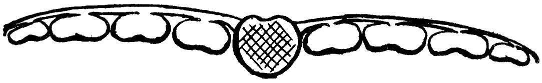

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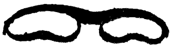

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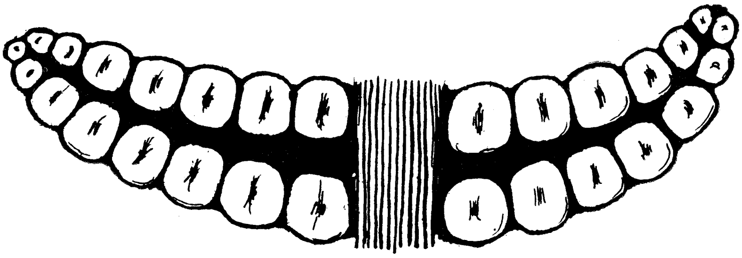

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1, 2. MATONIA PECTINATA R.BR.
3–6. MATONIDIUM AMERICANUM BERRY